Tribological Limitations in Gas Turbine Engines

A Workshop To Identify The Challenges and Set Future Directions

Sponsored By
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NASA/Glenn Research Center
Industrial Tribology Institute
Mohawk Innovative Technology, Inc.

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14. ABSTRACT

Early in the development of the gas turbine aircraft engine, tribology played a key supporting role in extending the life and performance of oil lubricated rolling element bearings permitting operation at ever higher speeds, loads and temperatures. A major factor in the success of rolling element bearings has been a clear understanding of the operating conditions and improvements in both bearing materials and lubricants. However, current projections and recent experience are that advancements to existing bearings and lubricants will likely only be incremented at best.

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Objectives:

Explore limitations of and advances needed for current and future air craft gas turbine engine bearings, including existing rolling element bearings and alternative technologies that may provide design freedom such as air foil bearings, novel seals, rotordynamic analyses and related technologies.

Benefits:

Guidance and direction to maintain U.S. global competitiveness will be provided for focused and accelerated developments and applications of revolutionary technologies in gas turbine engines.

Description:

Early in the development of the gas turbine aircraft engine, tribology played a key supporting role in extending the life and performance of oil lubricated rolling element bearings permitting operation at ever higher speeds, loads and temperatures. A major factor in the success of rolling element bearings has been a clear understanding of the operating conditions and improvements in both bearing materials and lubricants. However, current projections and recent experience are that advancements to existing bearings and lubricants will likely only be incremental at best.

This workshop has, as its goal the exploration of current rolling element bearing technology limitations in aircraft gas turbine engines. Further, this workshop will investigate the design freedom that may result from alternative rotor support technologies, such as compliant foil air bearings, hybrid foil/magnetic bearings, improved seals, rotordynamic analyses and related technologies.

It is expected that the major issues and benefits concerning the adoption of new bearing technologies will be highlighted. Keynote speakers and discussion leaders are being sought for this workshop. The workshop results will be documented in an effort to provide valuable guidance for future research on revolutionary oil-free aircraft engines.

Co - Chairs

Dr. Christopher Della Corte (NASA)

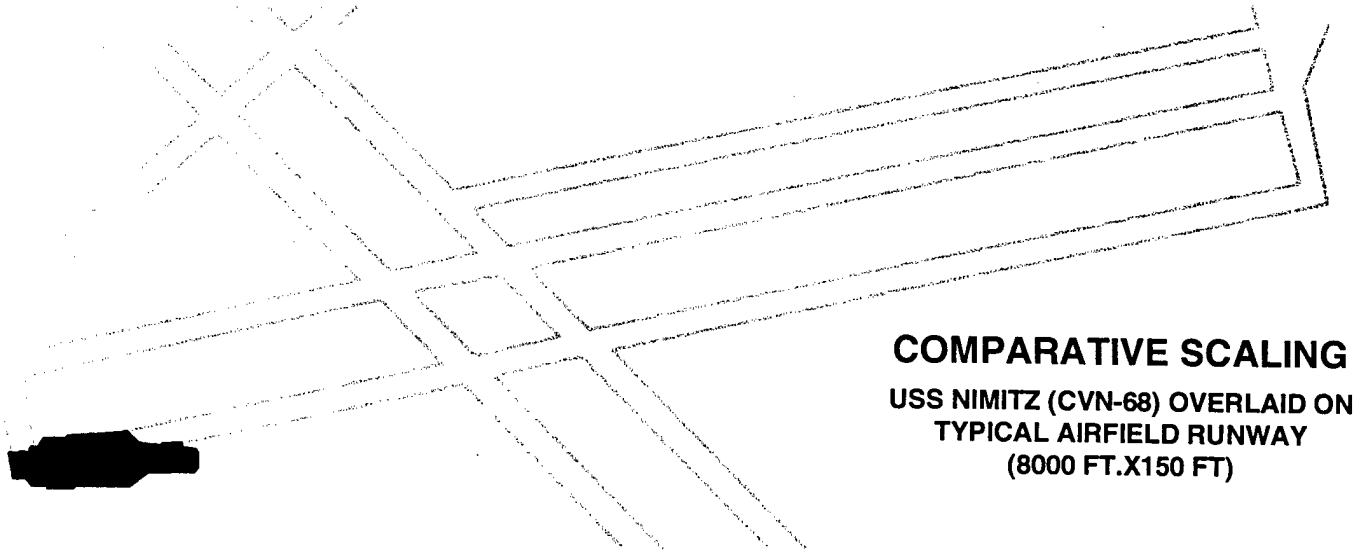
Dr. Hooshang Heshmat (MiTi)

Tribological Limitations From a User's Perspective: Naval Air Systems

Darrell Grant
Naval Air Warfare Center Aircraft Division
Naval Air Systems Command

The Business We Are In

- Develop, acquire and support aircraft and related systems which can be operated and sustained <u>at sea</u>
- Work with industry on behalf of the user to deliver our products and services



COMPARATIVE SCALING

USS NIMITZ (CVN-68) OVERLAID ON TYPICAL AIRFIELD RUNWAY (8000 FT.X150 FT)

We Are Different

Navy Propulsion Environment

BASING, OPERATIONS AND ENVIRONMENT

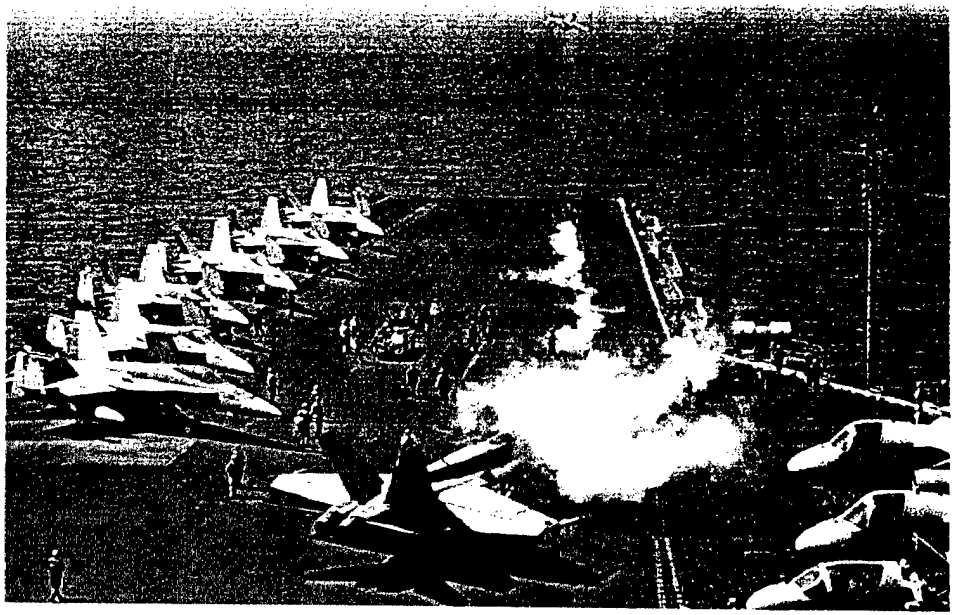
NAVY AIRCRAFT DO EVERYTHING THAT LAND BASED AIRCRAFT DO...BUT IN A MORE HOSTILE ENVIRONMENT AND UNDER MORE ADVERSE CONDITIONS

MISSIONS
- LOITER AND CRUISE SEGMENTS
- MULTI-MISSION CAPABLE
- V/STOL

CATAPULT TAKEOFF AND ARRESTED LANDING
- HIGH IMPACT STRUCTURAL LOADS
- HIGH THERMAL/CYCLIC LOADING
- RAPID, PRECISE THROTTLE CHANGES

ENVIRONMENT
- HIGHLY CORROSIVE SALT AIR/SPRAY
- HIGH HUMIDITY
- HIGH FOD, STEAM INGESTION, AND EMI

LIMITED SPACE
- MAINTENANCE/STORAGE
- SUPPORT EQUIPMENT



AIRCRAFT CARRIER TO SCALE

TYPICAL 300'x10,000' RUNWAY

Our Core Processes

We execute on behalf of the fleet

[redacted]

Perform acquisition management for the development, production, and in-service support of aircraft and weapons systems

[redacted]

Test and evaluate aircraft, weapons and integrated systems

[redacted]

Provide for the repair and/or modification of aircraft, engines, systems and components

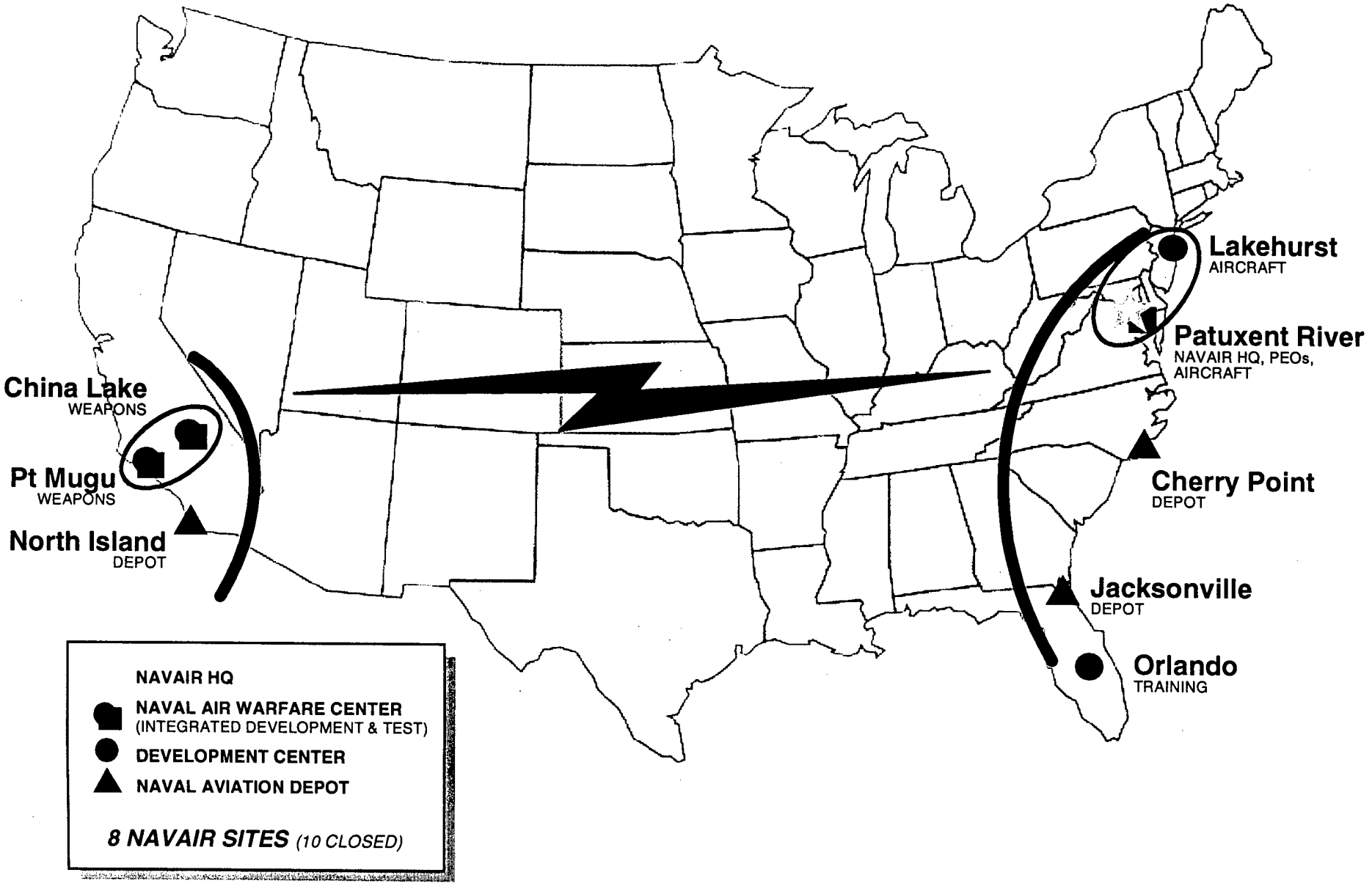
[redacted]

Provide for in-service engineering and logistics support

[redacted]

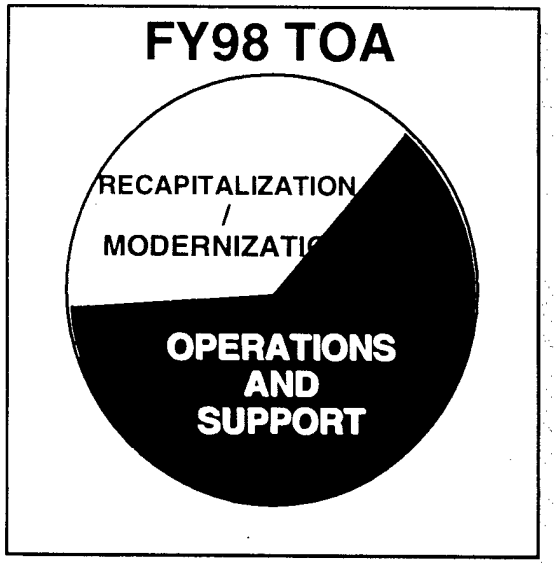
Conduct efforts focused on the advancement of technology, research and development and delivery of software / hardware products

NAVAIR Major Sites



Affordable Readiness

THE METHODS / MEANS NAVAL AVIATION IS USING TO:



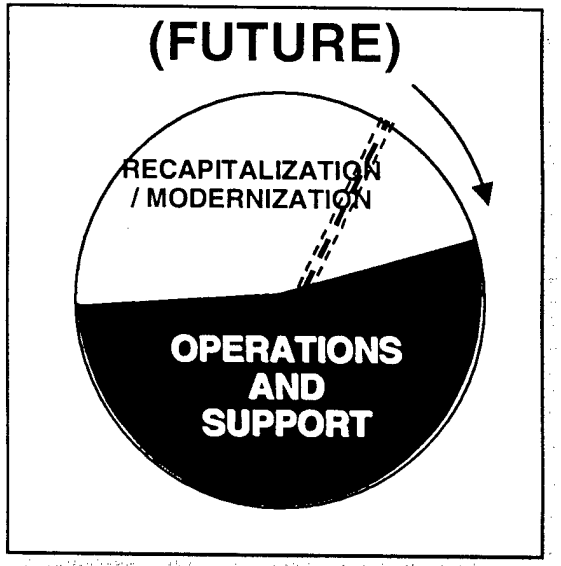
MAINTAIN SAFETY

SUSTAIN READINESS

REDUCE O&S COSTS

RECAPITALIZE

MODERNIZE



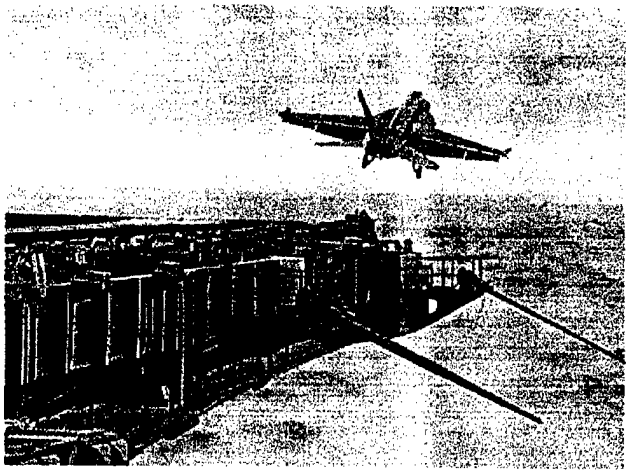
INCREASE FUNDS AVAILABLE FOR RECAPITALIZATION & MODERNIZATION

COST DRIVERS WE CAN IMPACT

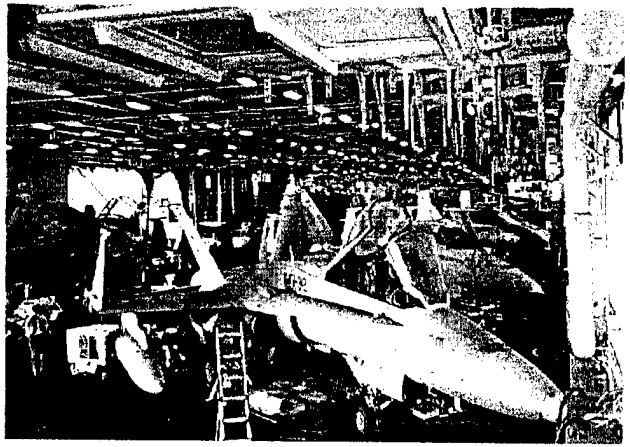
•INVENTORY •MANPOWER •TECHNICAL DATA •INFRASTRUCTURE

The Environmental Challenge

Long Life, Corrosion and Damage Tolerance Are Vital



To Reduce Maintenance Cost & Improve Mission Readiness



Technology Approach

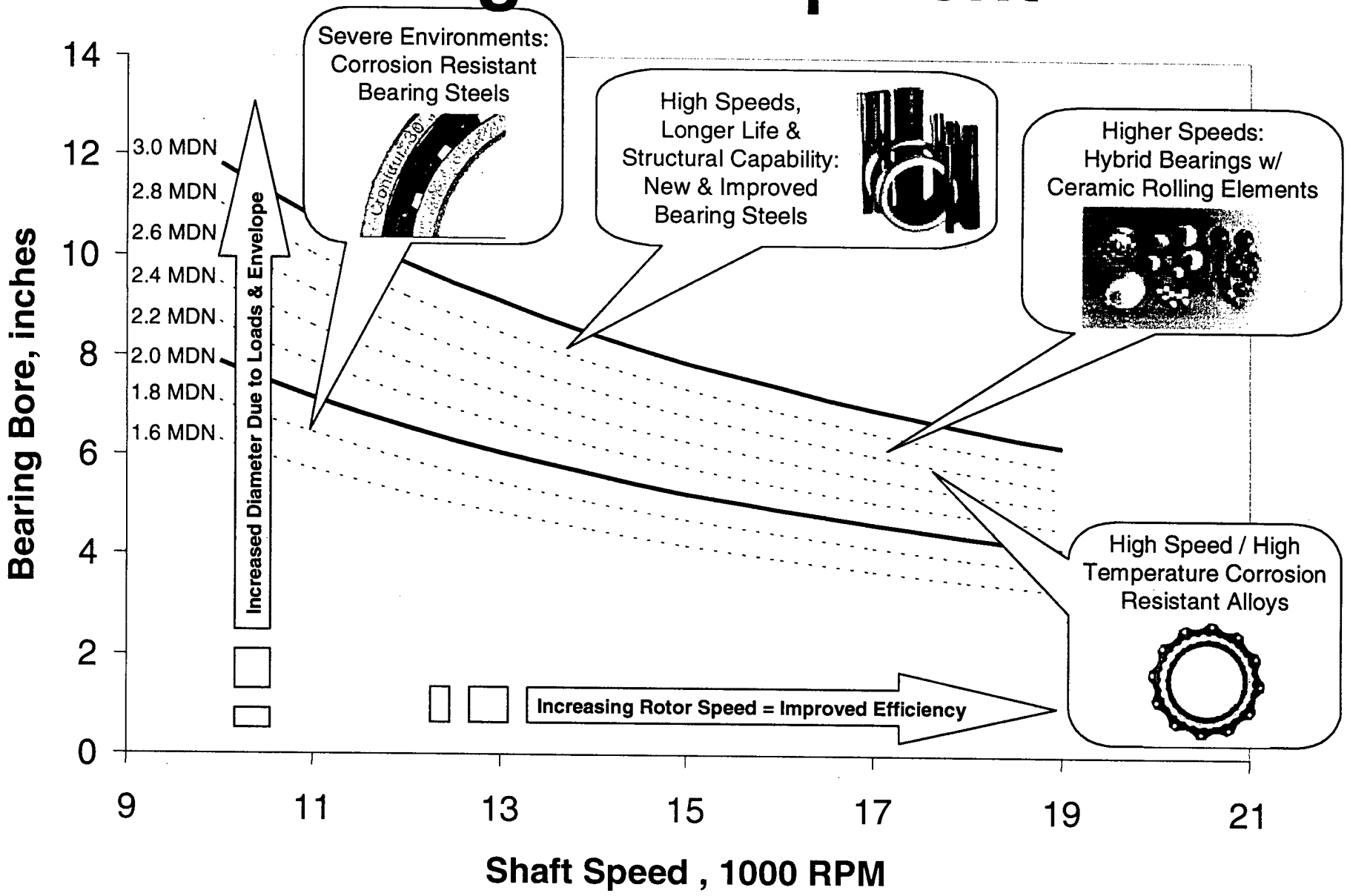
Near Term "Evolutionary"

- Corrosion Inhibited Lubricants
- Corrosion Resistant Bearings & Gears
- Longer Life / Higher Load Capacity Components
- Improved Seals

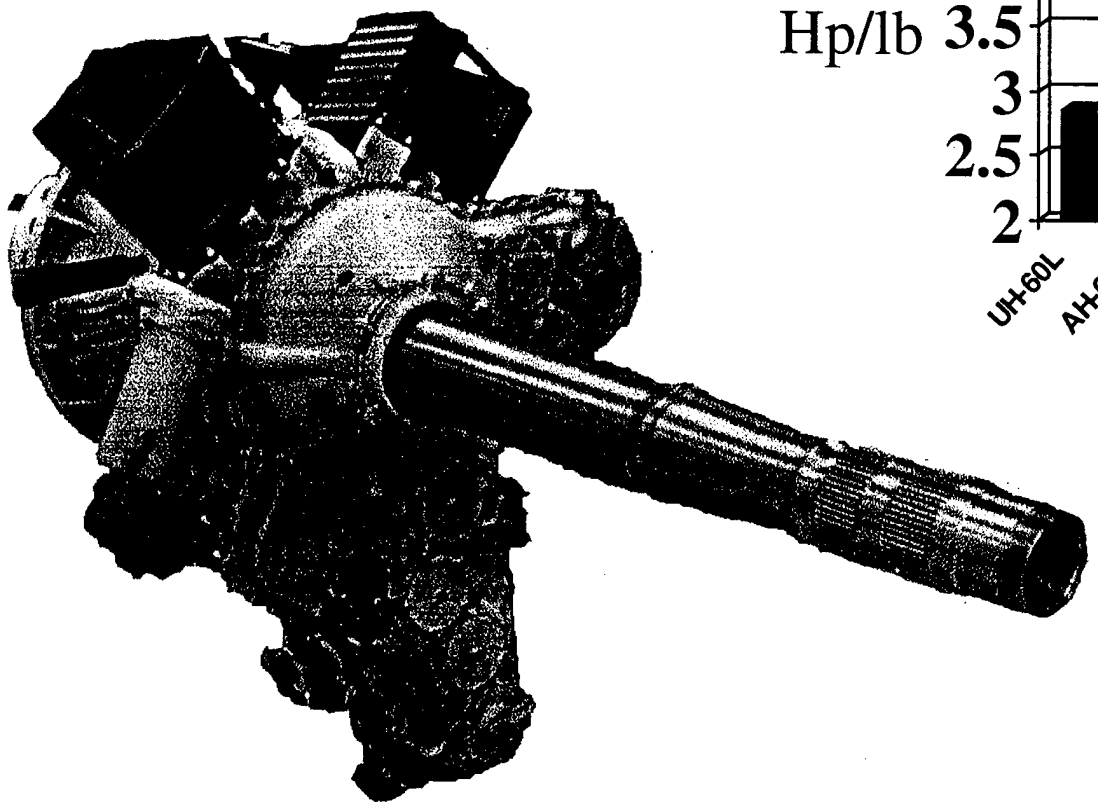
Far Term "Revolutionary"

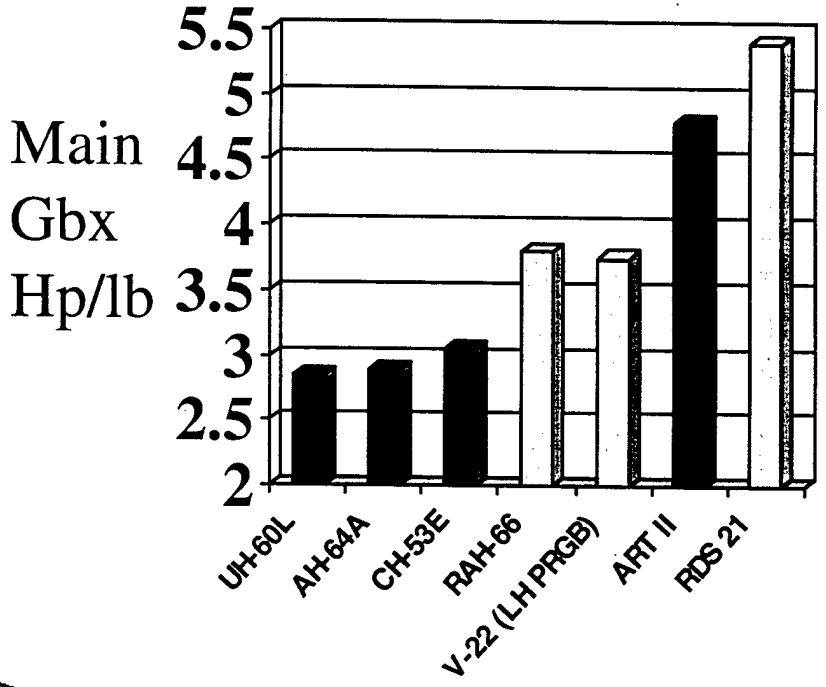
- Requirements from New System Capabilities
- Alternative Configurations Made Possible by Expanding SOA

Bearing Development

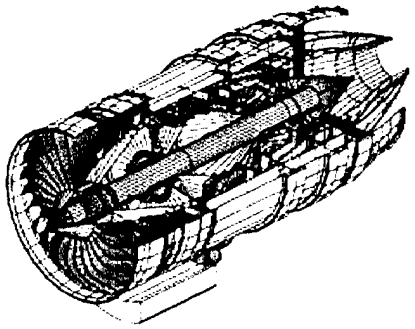


Drive System Development



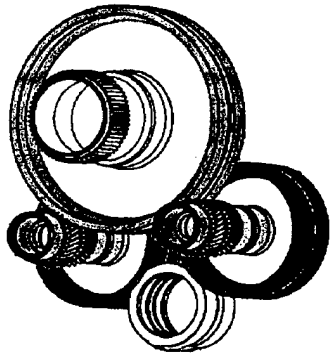


Programs

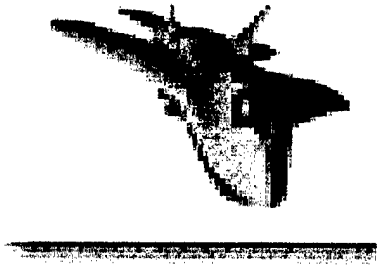


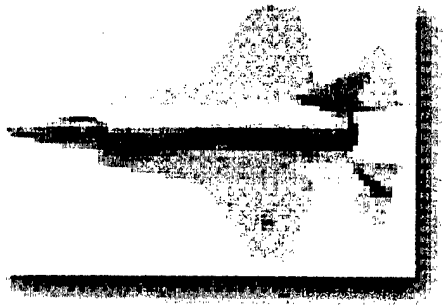
IHPTET 6.2 & 6.3 Funding
Dual Use S&T
Small Business Innovative Research

Advanced Rotorcraft Technologies

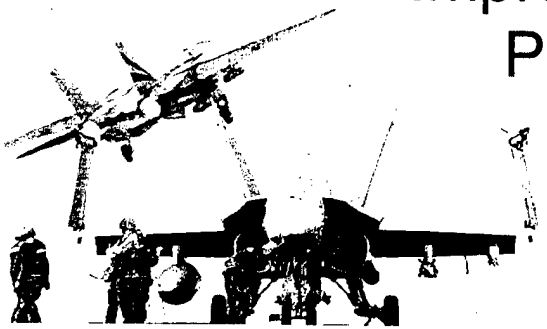


Joint Strike Fighter





Component Improvement Programs



CANDIDATE FUTURE NAVAL CAPABILITIES

- Information Distribution (Includes FLB ACTD)
- Time Critical Strike
- Decision Support System
- Autonomous Operations
- Littoral ASW
- Naval Gunfire Support
- Missile Defense
- Platform Protection
- Expeditionary Logistics
- Mine Warfare
- Littoral Undersea Warfare

Existing:
- Organic MCM
- DD21 (distributed ... others)

Autonomous Operations

- Autonomous systems
  - vehicles
  - payloads
- Extend the horizon for:
  - intelligence
  - surveillance
  - reconnaissance
  - tactical engagement
  - tactical logistics service

Autonomous Operations (Air) Goals/Objectives

- Demonstrate **Naval Unit Autonomy**: the ability of the Unmanned Aerial Vehicle (UAV) system to operate from Navy & Marine Corps units at sea and deployed ashore, and be controlled by, and interact with their associated human-centered command & control stations.
- Demonstrate a high degree of **UAV System Self-reliant/intelligent Autonomy**: the ability of the UAV system to perform critical Naval missions at extended ranges over the horizon, and with greatly reduced cost, human interaction, and human risk

Total Ownership Cost

- Reduce total ownership costs
  - longer life components
  - design and manufacturing improvements
  - enhanced maintenance
- Power & Power Distribution (DD21)
  - Electronically Reconfigurable Ship
- Hull & Mechanical Systems (DD21)
- Condition Based Maintenance (DD21)

Total Ownership Cost Goals/Objectives

To *develop, demonstrate effectively and transition* to the Fleet technologies and products that will reduce the total ownership costs of Navy resources.